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COMPACTING CHARACTERISTICS OF AL-15%Pb-FLY ASH METAL MATRIX COMPOSITES

Seelam Pichi Reddy[1] Bolla Ramana[1] and Chennakesava Reddy A [2]

[1] L.B.Reddy College of Engineering, Mylavaram, Andra Pradesh -521230, India.
[2]JNTU College of Engineering, Hyderabad, Andra Pradesh-500085, India.

ABSTRACT

Metal Matrix Composites (MMCs) are engineering materials formed by combination of two or more dissimilar materials of which atleast one is a metal. In the present investigation Al-15%Pb powders containing 0, 5, 10, 15 and 20 weight % Fly Ash were prepared. The powder mixtures were compacted at pressures ranging from 200-400 Mpa. The effects of compaction pressure and fly ash content on green properties of compacts were determined. It was found that green density, ejection pressure and spring back increased and true porosity decreased with increasing compaction pressure. For a fixed compaction pressure increasing fly ash content was found to decrease ejection pressure and green density.

Keywords: *Metal Matrix Composites, Fly Ash Content, Ejection Pressure, Green Density.*

1. Introduction

Metal matrix composites are engineering materials formed by combination of two or more dissimilar materials of which atleast one is a metal. These have enhanced properties including higher strength, low thermal expansion, higher fatigue life and higher wear properties compared to those of their matrix alloys [1-5]. Aluminum is a remarkable metal which posses a combination of qualities that make it suitable for variety of applications. Its use is increasing because of its lightness, corrosion resistance, good formability and ability to provide a range of mechanical properties by processing, alloying and heat treatment. A number of Al-base bearing materials have been developed [6, 7] with various metallic and non metallic [8-10] additions to improve their antiseizing property. Among the metallic additions, Sn is the most common. However, Pb[11-16] has been tried as a substitute for Sn by various research workers because of its lower modulus of elasticity, hardness and cost as compared to those of Sn.

Leaded Aluminum alloys was produced by D.Nath[17,18] by powder metallurgy technique and they have observed minimum spring back and maximum green hardness and strength for Al-15%Pb. Fly Ash is a particulate waste material formed as a result of coal combustion in power plants, is one of the cheapest and low density reinforcement commonly used in Aluminum MMCs[19,20,5]. It is reported that addition of fly ash has reduced density and coefficient of thermal expansion and increased wear resistance and stiffness. Ramana et.al [21] studied the properties of aluminum fly ash alloy produced by conventional powder metallurgy technique. The present experimental investigation describes the preparation of green compacts with Al-15% Pb –Fly ash by conventional powder metallurgy processing and some of its compacting characteristics are discussed.

2. Experimental Procedure

The material used during the present investigation were commercially available powders of Al (99% pure)and lead (99.5 % pure).Fly Ash was collected from VTPS, Vijayawada, Krishna District, Andhra Pradesh, India. Mixtures of these powders containing Al-15%Pb and 0, 5, 10, 15 and 20 weight % Fly Ash were prepared and blended. The powders were compacted at 200,300 and 400 MPa using a uni-axial hydraulic press. Silicone fluid spray is used as a die wall lubricant. The properties like ejection pressure, green density, spring back, true porosity, of the compacts thus produced were evaluated.

3. Results and Discussions

3.1 Powder characteristics

The scanning electron micrographs of aluminum, lead and fly ash powder particles are shown in Figures 1, 2 and 3 respectively.

From Fig.1, it can be understood that the aluminum powder particles are in elongated spherical shape, wherein the typical length scales are much larger than the corresponding thickness/diameter. From Fig.2 it is concluded that the Fly Ash particles are in general globular. As high pressure hot gases surround the ash particles coming out of the boiler after the coal

**Corresponding Author - E- mail: seelamspr@yahoo.co.in*

combustion, the particles are tend to get globular shape. It is evident from the micrograph that there exists wide range of particle size right from as small as 5 microns to as high as 50 microns. From Fig.3 it can be concluded that the lead particles are near spherical and particle size range is in between 20-40 microns.

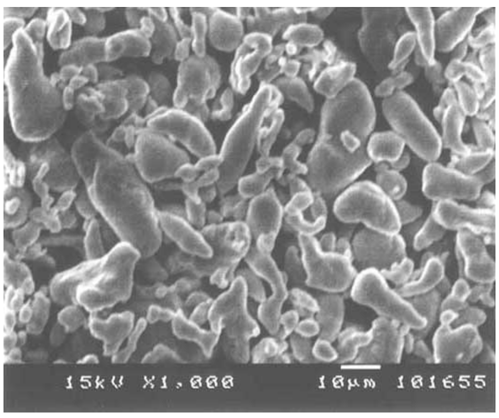

Fig. 1 SEM Photograph of Aluminum Powder

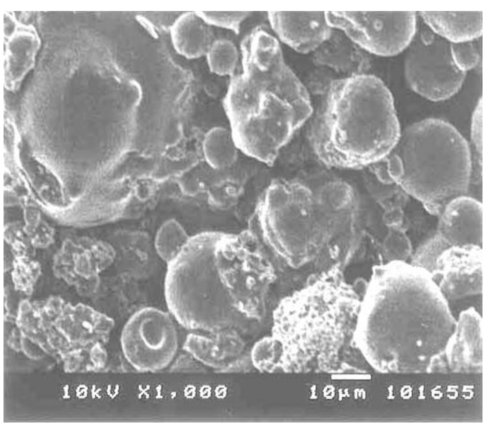

Fig. 2 SEM Photograph of Fly Ash powder

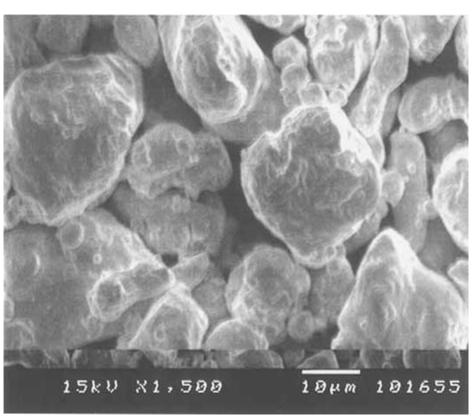

Fig. 3 SEM Photograph of Lead Powder

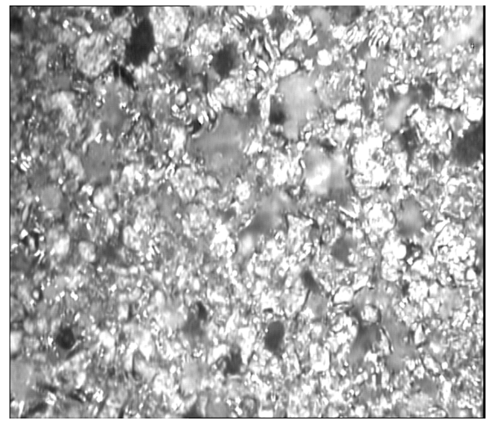

Fig. 4 Microstructure of Al-15% Pb-10%Fly Ash at 200 MPa

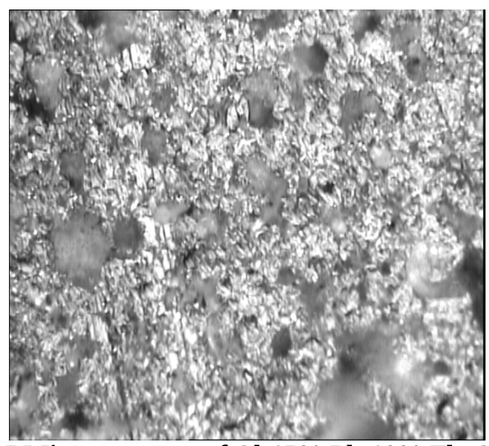

Fig. 5 Microstructure of Al-15% Pb-10% Fly Ash at 300 MPa

Fig. 6 Microstructure of Al-15% Pb-10% Fly Ash at 400 Mpa

3.2 Compacting Characteristics

The effect of compaction pressure and Fly Ash content on the ejection pressure is shown in Fig.7 & 8 respectively.

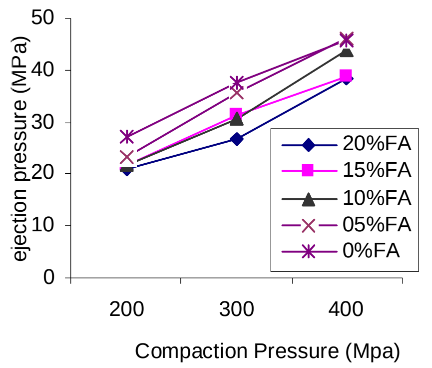

Fig. 7 Effect of Compaction Pressure on Ejection Pressure

The ejection pressure increases with compaction pressure and this may be due to increase in real area of contact between the die wall and compact with increasing compacting pressure as evident from Fig.4, 5 and 6. The ejection pressure decreases with increasing Fly Ash content. The gradual decrease in ejection pressure with increasing Fly Ash weight percent may be attributed to low frictional properties of spherical Fly Ash particles in the composite.

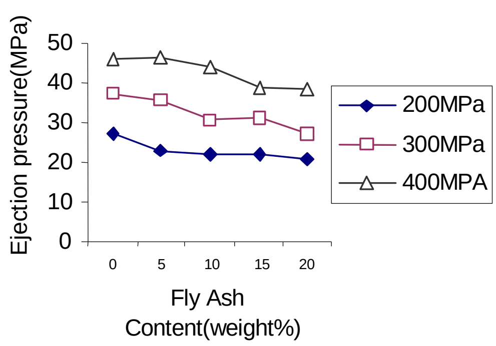

Fig. 8 Effect of Fly Ash Content on Ejection Pressure

As shown in Figures 9 & 10, the green density increases with increasing compaction pressure and decreases with increasing Fly Ash content. The increase in green density with increasing compaction pressure is the usual behavior of powder particles. Similar results have been reported by others [21, 22]. The decrease in green density with increasing Fly Ash content is obviously due to lower density of Fly Ash as compared to that of Al and Pb.

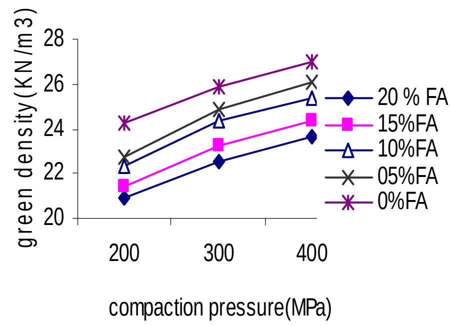

Fig. 9 Effect of Compaction Pressure on Green Density

Figure 11 indicates that spring back increases with increasing compaction pressure. The % true porosity decreases with increasing compaction pressure and increases with increasing Fly Ash content as shown in Fig.12 & 13 respectively. The percentage spring back is calculated using the equation

% Spring Back $=[(d_g - d_d)/d_d\,]\text{x }100$

Where

d_g = diameter of the green compact in mm

d_d = diameter of the die bore = 9mm

The percentage of true porosity is calculated using the equation

%True Porosity=

(1-(Green Density/True Density)) X 100.

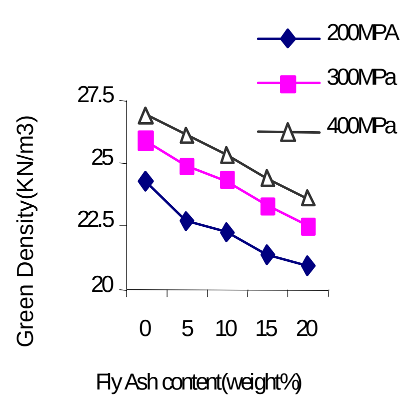

Fig.10 Effect of Fly Ash Content on Green Density

4. Conclusions

- The ejection pressure increased with increasing compaction pressure from 21.1 to 46.2 Mpa, whereas it decreased with increasing Fly Ash content.

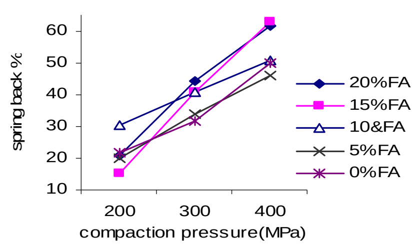

Fig.11 Effect of Compaction Pressure on Spring Back

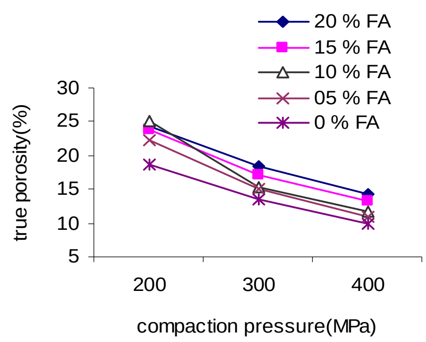

Fig. 12 Effect of Compaction Pressure on True Porosity

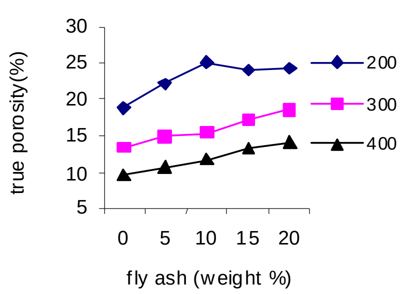

Fig. 13 Effect of Fly Ash on True Porosity

- The green density varies from 20.9 to 27 KN/m^3. It increased with increasing compaction pressure and decreased with increasing Fly Ash content.
- The % true porosity decreased with increasing compaction pressure from 25% to 9.7% and increased with increasing Fly Ash content.
- The % spring back increased with increasing compaction pressure from 15.2% to 62.6%.

References

1. *Rohatgi P K Ray and Sand Lill Y (1993), "Tribological Properties of Metal Matrix Graphite Particle Composites", Int. Mater., Vol. 37(3), 129-152.*
2. *Clync T W and Withers P J (1993), "An Introduction to Metal Matrix Composites", Cambridge University Press, New York.*
3. *Hoffman M, Skirl S, Pompe W and Rodel J, (1999), "Thermal Residual Strains and Stresses in Al2O3/Al Composites with Interpenetrating Networks", Acta Materialia, Vol. 47 (2), 565-577.*
4. *Kim J K, Kestursatya M and Rohatgi P K (2000), "Tribological Properties of Centrifugally Cast Copper Alloy- Graphite Particle Composite", Metallurgical and Materials Transactions A, Vol. 31 (4), 1283-1293.*
5. *Rohatgi P K, Gupta N and Simon Alaraj (2006), "Thermal Expansion of Aluminum Fly Ash Cenosphere Composites Synthesized by Pressure Infiltration Technique", Journal of Composite Materials, Vol. 40 (13), 1163-1174.*
6. *Pratt G C (1973), "Materials for Plain Bearings", International Materials Reviews, Vol. 18 (27), 58-62.*
7. *Evans C J (1980), "Tin in Plain Bearings", Tin and its Uses, Vol. 126, 8-12.*
8. *Surappa M K and Rohatgi P K (1978), "Production of Aluminum Graphite Particle Composites using Cu-Coated Graphite Particles", Metals Technology, Vol. 5, 358-361.*
9. *Nath D, Biswas S K and Rohatgi P K (1980), "Wear Characteristics and Bearing Performance of Alumina-Mica Particle Composite Materials", Wear, Vol. 60, 61-73.*
10. *Patton A M (1972), "Foundry Trails of Graphite-Containing Aluminum Alloys", Journal of Institute of Metals, Vol. 100, 197-201.*
11. *Eppich R E, Webbere F J and Dawson R N (1971), "A New Bearing Materials Cast From Immiscible Metals", Metals Engineering Quarterly, Vol. 11, 33-39.*
12. *Gorbunov G V, Parshin V D and Panin V V (1971), "Aluminum Graphite Antifriction Alloys", Russian Castings Production, Vol. 8, 348-353.*
13. *Tiwari S N, Pathak J P and Malhotra S L (1979), "Production of High Leaded Aluminum by Impeller Mixing", Metals Technology, Vol. 6, 442-445.*
14. *Raybould D (1982), "Wear –Resistant Al- Steel- Pb Admixed Alloys Produzced by Dynamic Compaction", Powder Metallurgy, Vol. 25, 35-41.*
15. *Gopinath M (1979), "Proceedings National Conference on Aluminum Metallurgy, IISc, Banglore, India, 289-294.*
16. *Mackay M.L (1977), "Innovation in Powder Metallurgy-An Engine Bearing Material", Metal Progress, Vol. 111, 32-35.*

17. *Nath D, Bolla R and Chandra S (1992), "Compacting Behaviour of Al-Pb Mixtures", Powder Metallurgy International, Vol. 24(2), 84-87.*

18. *Deo Nath, Raman Bolla and Sushil Chandra (1995), "Compacting and Sintering Behavior of Al-15% Pb Powder Mixture", Powder Metallurgy Science & Technology, Vol. 6(4), 25-31.*

19. *Mahendra K V and RadhaKrishna K (2007), "Fabrication of Al – 4.5% Cu Alloy with Fly Ash Metal Matrix Composites and its Characterization", Material Science – Poland, Vol. 25(1), 57-68.*

20. *Rohatgi P K, Guo R Q, Huang P and Ray S (1997), "Friction and Abrasion Resistance of Cast Al Alloy Fly Ash Composites", Metallurgical and Materials Transactions, Vol. 28(A), 245-250.*

21. *Bolla Ramana, Gunturi S. Murthy (2000), "Compacting Behaviour of Aluminum- Fly Ash Powder Mixture", 3rd National Symposium of Research Scholars on Metals and Materials, IIT Madras, Chennai.*

22. *Nia F and Davies B L (1982), "Production of Al-Cu and Al-Cu-Si Alloys by PM Methods", Powder Metallurgy, Vol. 25, 209-213.*

